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EXAMINER
KIELIN, ERIK J

ART UNIT	PAPER NUMBER
2813	11

DATE MAILED: 02/26/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/976,927	RAMANATH ET AL.	
	Examiner	Art Unit	
	Erik Kielin	2813	

-- Th MAILING DATE of this communication app ars on th cover sh t with th correspond nc address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *06 January 2003* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *12,13,15,17-19,21 and 24-28* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *12,13,15,17-19,21 and 24-28* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 7 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

This action responds to Applicant's Amendment filed 26 November 2002 (Paper No. 9), the Supplemental Amendment filed 6 January 2003 (Paper No 10) and the IDS filed 12 July 2002 (Paper No 7).

Information Disclosure Statement

Examiner acknowledges Applicant's remarks in response to the objection to the IDS that an IDS had been filed about one month prior to the mailing of the first Office action on the merits. This IDS was not, however, matched with the application until after mailing of the action and Examiner was clearly unaware that such IDS existed. Examiner apologizes on behalf of the Office for any inconvenience.

Nonetheless, the information disclosure statement filed 18 July 2002 fails to comply with the provisions of 37 CFR 1.97, 1.98 and MPEP § 609 because some of the references have not been provided with dates in accordance with 37 CFR 1.98(b)(5). Also the MPEP 609 states,

> "Each publication must be identified by publisher, author (if any), title, relevant pages of the publication, and **date** and place of publication. The date of publication supplied must include at least the **month and year** of publication, except that **the year of publication (without the month) will be accepted if the applicant points out in the information disclosure statement that the year of publication is sufficiently earlier than the effective U.S. filing date and any foreign priority date so that the particular month of publication is not in issue**." (Emphasis added.)

The IDS has been placed in the application file, but only the references initialed by Examiner have been considered. Applicant is advised that the date of any re-submission of any item of information contained in this information disclosure statement or the submission of any missing element(s) will be the date of submission for purposes of determining compliance with the requirements based on the time of filing the statement, including all certification requirements for statements under 37 CFR 1.97(e). See MPEP § 609 ¶ C(1).

Claim Rejections - 35 USC § 102

> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

1. Claims **12**, 13, 15 and **18**, 19, 21, and **24**-26, 28 are rejected under 35 U.S.C. 102(b) as being anticipated by US 5,079,600 (**Schnur** et al.).

Regarding claims 12, 18, and 24, **Schnur** discloses an integrated circuit or semiconductor device (Abstract) comprising a silicon substrate (Fig. 1A; col. 10, lines 28-29), a diffusion barrier layer (Fig. 1A, called "thin film"), and a metal (Fig. 3A; called "**metal**" and/or "**catalyst**" noting that the catalyst is also a metal --particularly palladium/tin, Pd/Sn) deposited on the diffusion barrier layer, wherein the diffusion barrier layer is covalently attached to the silicon substrate, and wherein the diffusion barrier is a self-assembled monolayer (col. 10, lines 42-47). (See also the sections entitled "EXAMPLE 1" col. 11, lines 24-58 wherein the barrier layer is formed from covalently bonded "octenyldimethylchlorosilane." See also "EXAMPLE 3," "EXAMPLE 5" and "EXAMPLE 28" col. 21.) It is seen to be inherent that the "thin film" is a diffusion

barrier, because it is the same thin film as disclosed and claimed by Applicant, and because the "metal" is on the "thin film" and is not shown in **Schnur** to diffuse through it, thereby meeting Applicant's definition of "diffusion barrier."

Moreover, **Schnur** states in col. 20,

> "EXAMPLE 24
> "Fabrication of MOS capacitor test structures.
> "An n-type silicon wafer with a 100 nm thick thermal oxide layer was cleaned and treated with UTF3 as in example 14. The film was patterned using a mask with standard capacitor test structures and irradiated for 28 minutes with an Hg/Ar lamp. The wafer was metallized with the standard copper plating procedures, used in Example 5, yielding metal squares 800 microns on a side (area=$6x10^{-3}$ cm^2). The metal/thermal oxide/n-type silicon (MOS) capacitors were then characterized by probing the metal pads and the back of the wafer with a Micromanipulator automatic C-V measuring system. The capacitance was found to be 26 pF/cm^2 with minimal (10 mV) hysteresis and remained stable at room temperature for at over 3 weeks, indicating that device degradation due to masked metal contamination (**diffusion of copper into the thermal oxide) was not a problem**. (Emphasis added.)

Accordingly, it is seen to be inherent that the SAM of **Schnur** is a diffusion barrier because **Schnur** states that "diffusion of copper into the thermal oxide" does not occur.

Further regarding claim 24, it is held absent evidence to the contrary that, the semiconductor device is capable of being biased at about 2 MV/cm at about 200 °C for about 30 minutes without diffusion of metal from the metal layer into the substrate. Basis for this reasoning is that Applicant is using the exact same SAM, as noted above, as is **Schnur** to form the barrier layer. **Schnur** also points out in Example 24 that copper diffusion does not occur even under the stress of an electric field. See *In re Swinhart*, 169 USPQ 226,229 (CCPA 1971) (where the Patent Office has reason to believe that a

functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the applicant to prove that subject matter shown to be in the prior art does not possess the characteristics relied on) and *In re Fitzgerald*, 205 USPQ 594 (CCPA 1980) (the burden of proof can be shifted to the applicant to show that subject matter of the prior art does not possess the characteristic relied on whether the rejection is based on inherency under 35 USC 102 or obviousness under 35 USC 103). Note that as long as there is evidence of record establishing inherency, failure of those skilled in the art to contemporaneously recognize an inherent property, function or ingredient of a prior art reference does not preclude a finding of anticipation. *Atlas Powder Co. v. IRECO, Inc.*, 190 F.3d 1342, 1349, 51 USPQ2d 1943, 1948 (Fed. Cir. 1999) (Two prior art references disclosed blasting compositions containing water-in-oil emulsions with identical ingredients to those claimed, in overlapping ranges with the claimed composition. The only element of the claims arguably not present in the prior art compositions was "sufficient aeration . . . entrapped to enhance sensitivity to a substantial degree." The Federal Circuit found that the emulsions described in both references would inevitably and inherently have "sufficient aeration" to sensitize the compound in the claimed ranges based on the evidence of record (including test data and expert testimony). This finding of inherency was not defeated by the fact that one of the references taught away from air entrapment or purposeful aeration.). See also *In re King*, 801 F.2d 1324, 1327, 231 USPQ 136, 139 (Fed. Cir. 1986); *Titanium Metals Corp. v. Banner*, 778 F.2d 775, 782, 227 USPQ 773, 778 (Fed. Cir. 1985).

Regarding claims 13 and 18, the self-assembled monolayer comprises subunits of the claimed structure wherein (1) R^2 is alkyl group (in "EXAMPLE 1") because octenyldimethyl is an alkyl group or, alternatively, a heteroaryl group (in "EXAMPLE 28") because pyridyl (from "pyridine") is a heteroaryl group, and wherein (2) the silicon atom is bonded to three oxygen atoms which are, in turn, presumably bonded near the substrate surface because at least in "EXAMPLE 28" *trichloro*-(4-pyridyl)-ethyl-silane is used and each of the chlorine atoms is chemically reactive and therefore replaced by Si-O bonds to the surface to "anchor" the molecule to the surface of the Si substrate (col. 10, lines 37-40). (For explicit verification of this inherency, see US 4,996,075 [**Ogawa** et al.] Fig. 1(b) and associated text at col. 2, lines 37-60.)

Regarding claims 15 and 21, see "EXAMPLE 28" noting that trichloro-(4-pyridyl)-ethyl-silane meets the structure limitations of the R^2 group wherein "ethyl" is the $(CH_2)_n$ group with n=2, "pyridyl" is the six-atom aromatic, nitrogen-containing group, and R^3 and R^4 are both hydrogen. Note that since the attachment of the ethyl group to the pyridyl group is at the "4" position (rather than the "2" position), the molecular structure limitation claims 17 and 23 are *not* met.

Regarding claim 25, as noted above, Example 24 in **Schnur** states that the substrate is a silicon wafer with silicon oxide formed thereon and copper is the metal.

Regarding claim 26, the terminal pyridyl group of Example 28 is aromatic.

Regarding claim 28, the metal layer is in direct contact with the terminal groups of the molecules in self-assembled monolayer (Fig. 1A). Note that the "catalyst" is a metal and therefore forms part of the "metal layer."

2. Claims **12**, 13, 15, 17, and **18**, 19, 21, and 23, and **24**-26, 28 are rejected under 35 U.S.C. 102(b) as being anticipated by US 5,389,496 (**Calvert** et al.) considered with **Schnur** and **Simon** et al. "Synthesis and characterization of a new surface derivitizing reagent to promote the adhesion of polypyrrole films to n-type silicon photoanodes: N-(3-(trimethyoxysilyl) propyl)pyrrole" Journal of the American Chemical Society, 104, Dec. 1982, pp. 2031-2034.

Regarding claims 12, 18, and 24, **Calvert** discloses an integrated circuit (sentence bridging cols. 10-11) comprising a silicon substrate (col. 10, lines 52-53), a diffusion barrier layer (called "chemical groups" or "catalyst ligating groups"), and a metal (col. 4, lines 58-61) deposited on the diffusion barrier layer, wherein the diffusion barrier layer is covalently attached to the silicon substrate (col. 3, 56 to col. 4, line 8), and wherein the diffusion barrier is a self-assembled monolayer.

Note that although no drawings are provided, the subject matter is virtually exactly same as that in the **Schnur** reference above **which is a parent patent** of the **Calvert** patent and is therefore incorporated by reference in its entirety, including the Figs. Accordingly, it is seen to be inherent that the covalently bonded "chemical groups" or "catalyst ligating groups" of **Calvert** inherently form a self-assembled monolayer which serves as a diffusion barrier for the reasons indicated above in reference to **Schnur**. Moreover, in "EXAMPLE 1" beginning in col. 12, the sentence bridging cols. 12 and 13 indicate that the "catalyst ligating group" (called now a "silane compound") provided *monolayer* coverage of the substrate (a silica slide in this example). Because the silane compound is bonded to the surface by reacting only with available surface sites, it is by definition also *self-assembled*. Accordingly, even without the benefit of the **Schnur**

reference, the diffusion barrier in **Calvert** is seen to be a self-assembled monolayer, covalently bonded to the surface of the substrate. Once the diffusion barrier is formed, it is treated with a catalyst and then electroplated (just as in **Schnur**) to form a metal layer on the diffusion barrier. (See **Calvert**, at least EXAMPLE 1 and EXAMPLE 20.)

Further regarding claim 24, it is held absent evidence to the contrary that, the semiconductor device is capable of being biased at about 2 MV/cm at about 200 °C for about 30 minutes without diffusion of metal from the metal layer into the substrate. Basis for this reasoning is that Applicant is using the exact same SAM, as noted above, as is **Schnur** to form the barrier layer. **Schnur** also points out in Example 24 that copper diffusion does not occur even under the stress of an electric field. See *In re Swinhart*, 169 USPQ 226,229 (CCPA 1971) (where the Patent Office has reason to believe that a functional limitation asserted to be critical for establishing novelty in the claimed subject matter may, in fact, be an inherent characteristic of the prior art, it possesses the authority to require the applicant to prove that subject matter shown to be in the prior art does not possess the characteristics relied on) and *In re Fitzgerald*, 205 USPQ 594 (CCPA 1980) (the burden of proof can be shifted to the applicant to show that subject matter of the prior art does not possess the characteristic relied on whether the rejection is based on inherency under 35 USC 102 or obviousness under 35 USC 103). Note that as long as there is evidence of record establishing inherency, failure of those skilled in the art to contemporaneously recognize an inherent property, function or ingredient of a prior art reference does not preclude a finding of anticipation. *Atlas Powder Co. v. IRECO, Inc.*, 190 F.3d 1342, 1349, 51 USPQ2d 1943, 1948 (Fed. Cir. 1999) (Two prior art references disclosed blasting compositions containing water-in-oil emulsions with identical

ingredients to those claimed, in overlapping ranges with the claimed composition. The only element of the claims arguably not present in the prior art compositions was "sufficient aeration . . . entrapped to enhance sensitivity to a substantial degree." The Federal Circuit found that the emulsions described in both references would inevitably and inherently have "sufficient aeration" to sensitize the compound in the claimed ranges based on the evidence of record (including test data and expert testimony). This finding of inherency was not defeated by the fact that one of the references taught away from air entrapment or purposeful aeration.). See also *In re King*, 801 F.2d 1324, 1327, 231 USPQ 136, 139 (Fed. Cir. 1986); *Titanium Metals Corp. v. Banner*, 778 F.2d 775, 782, 227 USPQ 773, 778 (Fed. Cir. 1985).

Regarding claims 13, 15, 17, 19, 21, and 23, "EXAMPLE 1" col. 12, "EXAMPLE 20" col. 18, "EXAMPLE 21" col. 19, each use the silane compound β-trimethoxysilylethyl-2-pyridine which leads, by reaction with the substrate surface, to the diffusion barrier having the structures as instantly claimed --particularly claims 17 and 23, which are further limiting examples of the structures in claims 15 and 21, respectively-- as further discussed below.

First, the "ethyl" syllable refers to the $(CH_2)_2$- group, the silyl to the Si, and the pyridine to the six-atom cyclic aromatic group containing the nitrogen wherein R^3 and R^4 are hydrogen. The trimethoxysilyl refers to $(CH_3O)_3Si$- group which, upon reaction produces the Si bonded to the 3 oxygen atoms which are, in turn, bonded near the surface of the substrate (as in instant claims 13 and 19). The "trimethoxy" portion of the compound is the counterpart to the "trichloro" portion in **Schnur,** above, which enables reaction with the substrate surface. (For verification that the trimethoxysilyl group

inherently leads to the three Si-O bonds as instantly claimed, see the article **Simon** et al. "Synthesis and characterization of a new surface derivitizing reagent to promote the adhesion of polypyrrole films to n-type silicon photoanodes: N-(3-(trimethyoxysilyl) propyl)pyrrole" Journal of the American Chemical Society, 104, Dec. 1982, pp. 2031-2034 --especially see the second page, the left-hand column, and Fig. 1 in the right-hand column.)

Regarding claim 25, Example 20, col. 18, states that the substrate is a silicon wafer with silicon oxide formed thereon and that the metal may be copper (col. 4, lines 58-61).

Regarding claim 26, the terminal pyridyl group of Example 21, col. 19, is aromatic.

Regarding claim 28, the metal layer is in direct contact with the terminal groups of the molecules in self-assembled monolayer (Fig. 1A). Note that the "catalyst" is a metal and therefore forms part of the "metal layer."

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claim 27 is rejected under 35 U.S.C. 103(a) as being unpatentable over either of **Schnur** and **Calvert**, either in view of **Wolf**, et al. Silicon Processing for the VLSI Era,

Vol. 1-Process Technology, 2nd ed., Lattice Press: Sunset Beach CA, 2000, pp. 438, 782-783.

Each of **Schnur** and **Calvert** discloses each of the claimed features, as explained above, but does not indicate that the metal layer is deposited by a vapor deposition process, using in the exemplary embodiments, electroplating. **Schnur** does, however, indicate that the metal deposition method is for use in interconnect for semiconductor microcircuitry (Abstract, Example 25 in col. 20.)

The basic textbook of **Wolf**, teaches that copper metal interconnect may be deposited by a variety of methods, including electroplating and vapor deposition methods such as PVD (e.g. sputtering; Wolf p. 438) and CVD. (See pp. 782-783--especially p. 783, last paragraph before section 15.8.2.)

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use a vapor deposition process, such as sputtering, to deposit the metal layer in **Schnur** or **Calvert**, because vapor deposition processes (i.e. PVD and CVD) are an art recognized equivalent means to the electroplating used in **Schnur** or **Calvert** to form copper interconnect, as taught by **Wolf**.

Response to Arguments

5. Applicant's arguments filed 26 November 2002 and 6 January 2003 have been fully considered but they are not persuasive.

Each of Applicant's arguments is predicated on the assertion that **Schnur** and **Calvert** do not teach a diffusion barrier. This runs in direct contradiction to the facts of record. To repeat, Example 24 in col. 20 of **Schnur** states, "diffusion of copper into the

thermal oxide[] was not a problem." This is the exact function of a diffusion barrier, as defined by Applicant in the instant specification. Accordingly, the SAM of **Schnur** was observed to be a diffusion barrier. Use of Applicant's terminology, i.e. "diffusion barrier." is not a requirement for anticipation.

Moreover, it is noted that the Declaration submitted by Shyam Muraka also fails to provide evidence that the **Schnur** SAM is not a barrier layer to copper diffusion. Paragraph 3 of the Declaration states, that Dr. Muraka reviewed the Office action and the Patents of Schnur and Calvert. Paragraph 6 states,

> "Contrary to the assumption in the rejections based on Schnur '600 and Calvert '496, I do not believe that either reference "Inherently" discloses a "diffusion barrier". Neither Schnur '600 nor Calvert '496 describe or suggest self-assembled monolayers that are diffusion barriers. For example, neither Schnur '600 nor Calvert '496 tested their structures like the present inventors to show that copper diffusion does not occur under conditions such as thermal bias annealing. Consequently, I do not believe that the inventions defined by claims 6-20, each of which recites a "diffusion barrier", in the Amendment are "inherent" in Schnur '600 or Calvert '496.

In this regard, MPEP 2145, states that "argument does not replace evidence where evidence is necessary." Accordingly, it is respectfully submitted that the opinions of Dr. Muraka are inconsequential because they do not constitute evidence and, furthermore, fail to address the facts presented in **Schnur** --especially that **Schnur** observed that the SAM used therein prevented copper diffusion into silicon dioxide. As noted above, because the Schnur provides evidence of inherency for the Calvert patent.

Conclusion

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

US 5,077,085 (**Schnur** et al.), US 5,468,597 (**Calabrese** et al.), US 5,500,315 (**Calvert** et al.), US 5,510,216 (**Calabrese** et al.), US 5,648,201 (**Dulcey** et al.), US 6,348,240 B1 (**Calvert** et al.) each are related patents and share common inventors to the **Schnur** and **Calvert** references applied above and are believed to anticipate at least the independent claims, as presently claimed.

US 5,057,339 (**Ogawa**) in Fig. 1C anticipates at least instant claims 12, 13, 18, and 19.

US 5,939,150 (**Stelzle** et al.) anticipates at least instant claims 12 and 18.

7. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Erik Kielin whose telephone number is 703-306-5980. The examiner can normally be reached on 9:00 - 19:30 on Monday through Thursday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr., can be reached at 703-308-4940. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9318 for regular communications and 703-872-9319 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Erik Kielin
February 23, 2003